



Advanced Computer Systems

SPACE
division

acs

COMPACT GROUND STATION FOR ENVISAT ASAR

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FOREWORD

With more than twenty years of experience in design, developing and delivery of Earth Observation Data processing systems, **Advanced Computer Systems SpA (ACS)**, based in Rome Italy, is the leading company in this field. More than twenty systems are today in operation in many countries, within and outside Europe. They are all based on a common **Multi-satellite Data Processing System (MDPS)**. ACS has presented over the years a number of innovative architectures, always marking a significant difference w.r.t. both previous systems and systems of other suppliers.

Now, ACS is pleased to announce to its Customers the availability of a new product:

the **ENVISAT ASAR Compact Station (ECS)**,

which is a specific customisation of the MDPS for ENVISAT/ASAR.

ACS solutions are always characterised by a large scalability of the hardware configuration, thus making it possible to host the ENVISAT Compact Station on a simple hardware configuration, which justifies the term "compact". This approach leads to an optimized trade-off between the cost of the system and the performance in terms of throughput, level of automation, redundancy etc.

Furthermore, ACS is in the position to provide **cost effective and technically advanced solutions**. The proposed system is a turn-key solution that allows the full exploitation of the capabilities offered by the Advanced Synthetic Aperture Radar (ASAR), opening the door to operational services based on SAR data. It allows the Customer to acquire the ASAR raw data coming from the ENVISAT satellite, to generate the ASAR standard products and to archive the products on media.

The Station can be easily upgraded to other satellites such as RADARSAT , LANDSAT, ERS, SPOT and TERRA/AQUA. These upgrades can be proposed as options for successive upgrades.

This document contains the description of the capabilities of the proposed solution.



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1 BACKGROUND

Advanced Computer Systems SpA (ACS) is a software house with all the engineering capabilities for integrating, delivery and maintenance of complete ground segments.

ACS proposes to its Customers proprietary software solutions, system integration and software/services for EO Applications mainly based on a multi-satellite architecture.

ACS Systems have been delivered and installed all over the world, to the European Space Agency and other major Agencies. All of the ground stations presented in the following figure are operational and currently under ACS maintenance.

The ENVISAT Compact Station offered in this proposal is a compact HW configuration of the Multisatellite Data Processing System (MDPS), which is an ACS COTS.

The MDPS has been implemented in the past for the following satellite/missions:

- ERS (1,2)
- SPOT (1-4)
- RADARSAT
- SRL/XSAR (1,2)
- LANDSAT (1-7)
- TERRA/AQUA (MODIS)
- JERS-1
- SRTM/XSAR

Now the implementation for ENVISAT/ASAR is available.

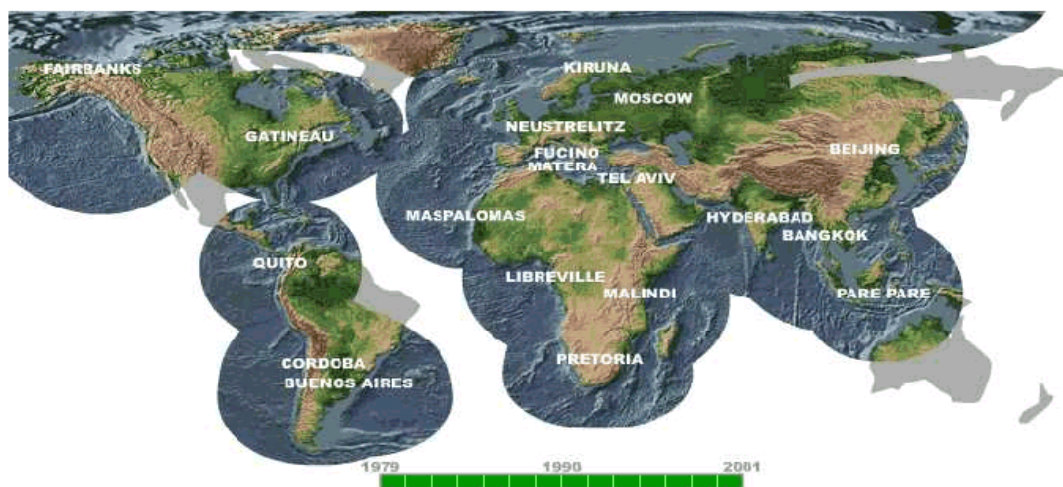


Figure 1 – ACS system installations in the world



The ACS concept of the receiving ground station is based on a Multi-satellite architecture, direct data ingestion, software synchronisation, data archiving on Computer Compatible Medium, advanced graphic interface and standard product generation.

Compared to the previous systems, this approach shows a big difference in terms of quality and cost and it guarantees the very best solution to the customer. It is worthwhile mentioning that ACS solutions have recently been adopted by ESA for the development of the CryoSat Payload Data Segment.

For less money invested, ACS offers a versatile system with reliable performances, effective throughput and facilitated use. Today, the ACS systems delivered to Ground Stations all over the world are more than 20, and they have represented the first direct ingestion implementation, proven and tested in operational environment.



2 ENVISAT COMPACT STATION TECHNICAL OVERVIEW

The **ENVISAT ASAR Compact Station (ECS)** is a processing system for ground stations comprising direct data ingestion (down-linked through the X-band link from ENVISAT satellite), software synchronization, data archiving on Computer Compatible Medium in ESA format, advanced graphical interface and standard product generation.

2.1 ECS FUNCTIONAL ARCHITECTURE

The ECS station is able to guarantee the following main functionalities:

- ingestion of ENVISAT ASAR data in real time, directly from the acquisition subsystem
- software synchronisation/formatting of ingested data
- data de-scrambling, and decoding
- temporary storage on disk array
- real-time monitoring of acquired data
- archiving data in ESA format on DLT (including a screening function to assess transcription quality)
- update and maintenance of local station acquisition catalogue with browse images (Quick Looks) and pass metadata
- generation of standard products.

The ECS has as support functions:

- reception and storage of pass related information (state vectors, etc.)
- reception and storage of periodically distributed information (calibration data)
- acquisition screening, quick looks generation and acquisition quality assessment
- tape back-up function
- interface with mission control centre

This fully integrated, Multisatellite system is based on a completely software approach. All the functions implemented are written in high level languages (C, C++ and Java).

Beside the general-purpose hardware equipment, the system configuration also includes an ingestion board. This specific piece of hardware accepts the satellite data stream and transfers it into the computer memory. The only function of this board is to convert the ECL signal to TTL and no processing is done on the incoming flow.



The ENVISAT Compact Station Block-Diagram is here after reported.

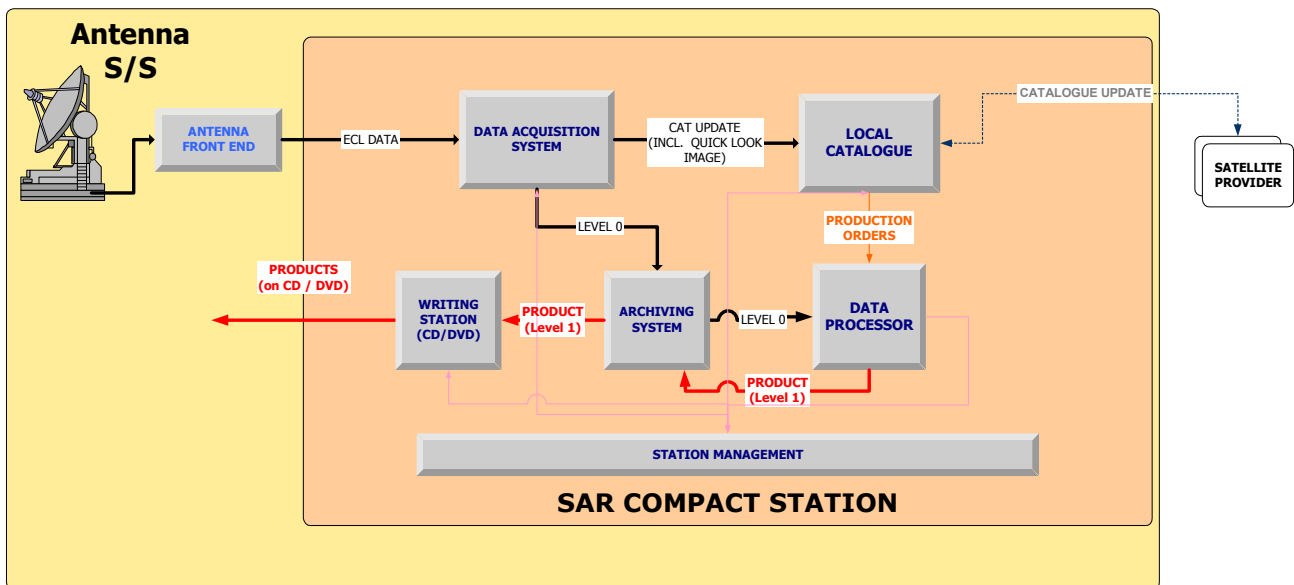


Figure 2 – ENVISAT SAR Compact Station Block-Diagram

In the following sections the ENVISAT Compact Station components are described.

Note: the ACS ENVISAT Compact Station has all Level 0 products in compliance with ESA specifications certified by ESA.



2.1.1 DATA ACQUISITION

The ECS system receives X-band data directly from the demodulator output. It has a complete, built-in test capability.

The data acquisition function is able to perform the following tasks:

- Real time acquisition and storage on disk
- Visualisation during acquisition of statistic values (histograms) for SAR data.
- Data quality assessments
- Level 0 products systematic production

The ingestion function is automatically launched by a watch dog plug-in by computing the contact timeliness of the satellite over the acquisition station (it shall also be possible to launch the acquisition manually or by implementing an acquisition plan). This SW activates ingestion few minutes before effective satellite entry in the station coverage mask.

The data ingestion will effectively start writing on the disk array only when valid data are found. The disk array can be easily sized to satisfy the required daily data load.

2.1.2 LOCAL CATALOGUE

The ECS System maintains a catalogue for the generated products including quicklooks. The ECS provides a greyscale (SAR) quicklook image for every raw image in the catalogue. The quicklook image is produced off-line w.r.t. ingestion operations.

A catalogue browse GUI enables queries and the selection of data and products from the local catalogue using spatial and attribute query criteria.

ACS has developed a modular object oriented approach for the Station's catalogue: the 'BRO family whose major representative product is **HyBro** (**HY**per **BRO**wser). It has been released in 2001 and is actually installed at IAI-MBT (Israel) Ground Station, and with the full-optional configuration, including the web interface, at SAC (South Africa) Ground Station. The catalogue has been designed as multi mission and is currently commercialised among the already existing Ground Stations.

The following figure shows the interactive interface (**HyBro**) that allows the user to perform spatial/temporal queries or just specific queries using devoted panels. The interface enables to navigate the map, highlighting the shapes resulting from the query if applicable.

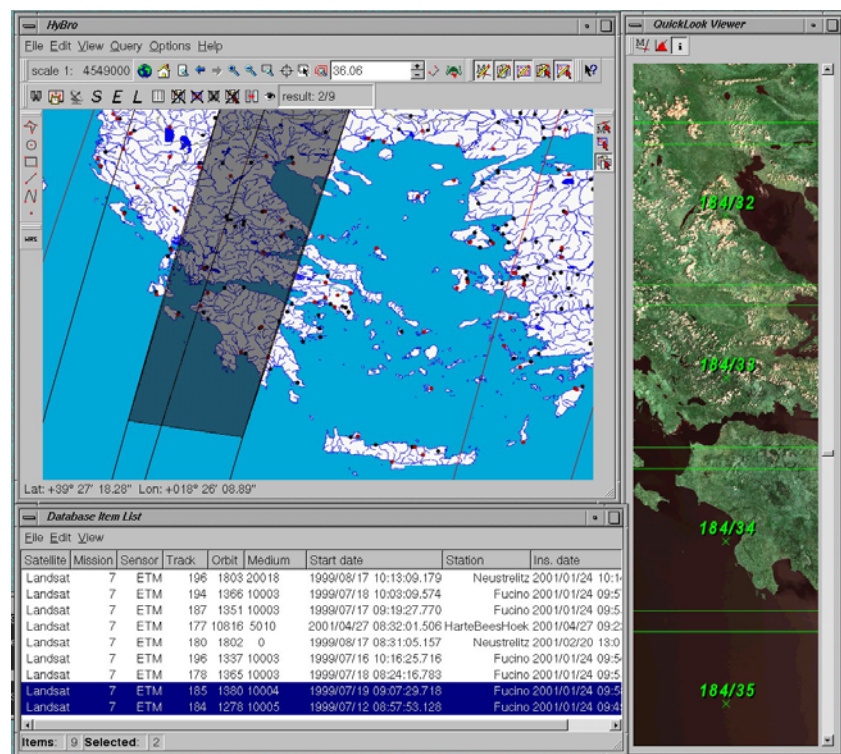


Figure 3 – Local Catalogue User Interface

The application is fully configurable in terms of interface/data and aspects and uses the State Of the Art technology for the user interface like dockable toolbars, tool tips, online help, *about this* help etc...

In order to search for the data, the user needs to select what to query for. There are many ways to accomplish this task and the application provides different panels to help the user in creating the query. As a significant example of a typical query like the ones to be performed in the MDPS system the following figure shows the *Spot Query Panel* where the user can select which field to use to filter the result. Only the filled ones will be used in the query; those ones with an *asterisk* are in their default state and will not narrow the query. The user can select any combination of fields. To start the query it suffices to click on the *Apply* button.



Figure 4 - Spot Query Panel (example)

Subsequently the application starts loading the results. If the retrieved items correspond to a geographical footprint, it will be drawn on the map.

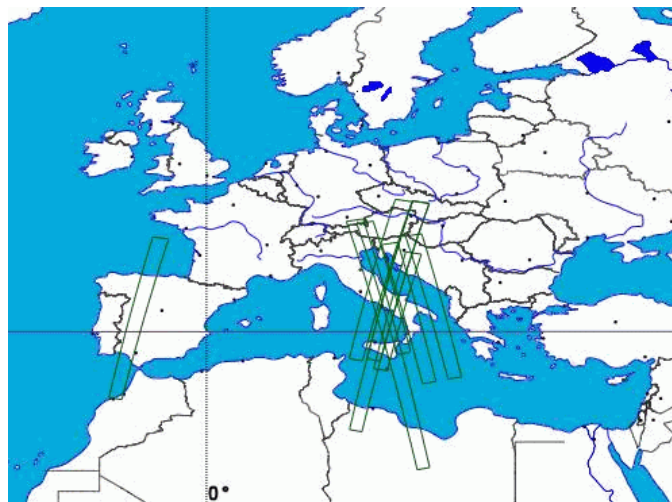


Figure 5 - Query result with segments shape (example)

In any case a list of the retrieved items (shown in the following figure) can be visualized by the user. The list can be customized to show all the fields or only a subset of them. The customisation can be saved in the application preferences on a per-user basis. Clicking on the fields' header the user can sort the list in ascending or descending order for that field. The list can be saved in HTML format and/or printed. Actions on selected items can be triggered using the mouse and the menu bar (configurable as well). If an item is selected, the map will highlight it.



Advanced Computer Systems

Compact Ground Station for ENVISAT ASAR

Ref.: ECS-EO-ACS-OF-0001

File Edit View									
Satellite	Mission	Sensor	Track	Orbit	Medium	Start date	Station	Ins. date	
Spot	2	Xs	143	126	362	2000/01/02 07:57:42.467	HarteBeesHoek	2001/02/10 03:35:46.510	
Spot	2	Pan	143	126	361	2000/01/02 07:57:40.133	HarteBeesHoek	2001/02/10 03:35:45.429	
Spot	2	Xs	140	126	361	2000/01/02 07:56:47.030	HarteBeesHoek	2001/02/10 03:35:43.992	
Spot	2	Xs	148	126	362	2000/01/02 07:56:45.967	HarteBeesHoek	2001/02/10 03:35:42.557	
Spot	2	Xs	136	126	361	2000/01/02 07:56:01.326	HarteBeesHoek	2001/02/10 03:35:41.337	
Spot	2	Xs	151	126	362	2000/01/02 07:56:00.178	HarteBeesHoek	2001/02/10 03:35:38.998	
Spot	2	Xs	149	126	362	2000/01/02 07:54:53.662	HarteBeesHoek	2001/02/10 03:35:37.148	
Spot	2	Xs	143	126	362	2000/01/02 07:57:59.707	HarteBeesHoek	2001/02/10 03:35:47.325	
Spot	2	Xs	140	126	362	2000/01/02 08:00:28.512	HarteBeesHoek	2001/02/10 03:35:59.471	
Spot	2	Xs	135	126	361	2000/01/02 08:00:26.691	HarteBeesHoek	2001/02/10 03:35:58.524	
Spot	2	Xs	138	126	362	2000/01/02 07:59:40.480	HarteBeesHoek	2001/02/10 03:35:55.574	
Spot	2	Xs	135	126	361	2000/01/02 07:59:35.668	HarteBeesHoek	2001/02/10 03:35:52.687	
Spot	2	Xs	138	126	361	2000/01/02 07:58:48.546	HarteBeesHoek	2001/02/10 03:35:51.649	
Spot	2	Xs	146	126	362	2000/01/02 07:58:46.828	HarteBeesHoek	2001/02/10 03:35:50.405	
Spot	2	Xs	143	126	361	2000/01/02 07:58:00.052	HarteBeesHoek	2001/02/10 03:35:48.092	
Spot	2	Xs	150	126	361	2000/01/02 07:54:52.691	HarteBeesHoek	2001/02/10 03:35:35.330	
Spot	4	Xi	150	367	362	2000/01/02 07:28:51.569	HarteBeesHoek	2001/02/10 03:35:18.562	
Spot	4	Xi	150	367	361	2000/01/02 07:28:26.606	HarteBeesHoek	2001/02/10 03:35:17.187	
Spot	4	Xi	151	367	362	2000/01/02 07:28:24.246	HarteBeesHoek	2001/02/10 03:35:15.573	
Spot	4	Xi	150	367	361	2000/01/02 07:28:09.493	HarteBeesHoek	2001/02/10 03:35:14.140	
Spot	4	Xi	150	367	362	2000/01/02 07:28:00.246	HarteBeesHoek	2001/02/10 03:35:12.753	
Spot	4	Xi	150	367	361	2000/01/02 07:27:34.992	HarteBeesHoek	2001/02/10 03:35:11.425	
Spot	4	Xi	151	367	362	2000/01/02 07:27:34.045	HarteBeesHoek	2001/02/10 03:35:10.526	

Items: 66 Selected: 1

Figure 6 - Query Result with retrieved items list (example)

Once selected, an Item can be queried additionally to have its full description (see the following figure).

Owing to the strong object oriented approach, each object can represent itself in HTML format that can be visualized, printed and/or saved as an html file. With very little effort, the software can be customized to send the HTML content by e-mail.

Hydra

File

Segment data																				
Sat.	Miss.	sensor	asc. flag	station	insert. date	beg. record date	end record date	orbit	cycle	i lat min	i lon min	i lat max	i lon max							
Spot 4		M	False	Fucino	22-SEP-2000_21:04:38.766	07-DEC-1999_10:35:10.137	07-DEC-1999_10:35:36.020	369	0	40.0809	7.81382	39.952	7.81382							
Medium																				
ID	Type																			
465	DLT																			
SPOT segment data																				
Num.	hrv num	mode	channel	gain	beg. time	end time	qual. factor	look. angle	miss. lines flag	hrv conf.	mirror step	triode qfactor								
0	1	M	2	6000	07-DEC-1999_10:35:10.137	07-DEC-1999_10:35:36.020	0	13.0272	False	Bindependent	70	5								
Frame																				
frame	print frame	order	cloud	track	ll lat	ur lon	ur lat	ul lon	ul lat	ll lon	lr lat	lr lon	processable	miss. lines	Quality f.	center time cod	sc lat	sc lon	incidence	orientation
267			**00	58	8.17	41.1	9.12	41.4	8.37	41.6	8.91	40.9	True	2589	2	10:35:14.649	41.2514	8.63987	14.7628	13.2345
268			0000	58	7.99	40.6	8.93	41	8.19	41.1	8.73	40.4	True	0	20	10:35:23.076	40.7652	8.45454	14.7625	13.12
269		----	00**	58	7.81	40.1	8.74	40.5	8.01	40.6	8.54	40	False	2156	5	10:35:31.508	40.2785	8.27149	14.7623	13.008

Figure 7 - Query Result detailed panel (example)

The order panel depicted in the following figure can be called from the "detailed panel" by clicking on the order icon of a selected frame. The order panel is presented below.

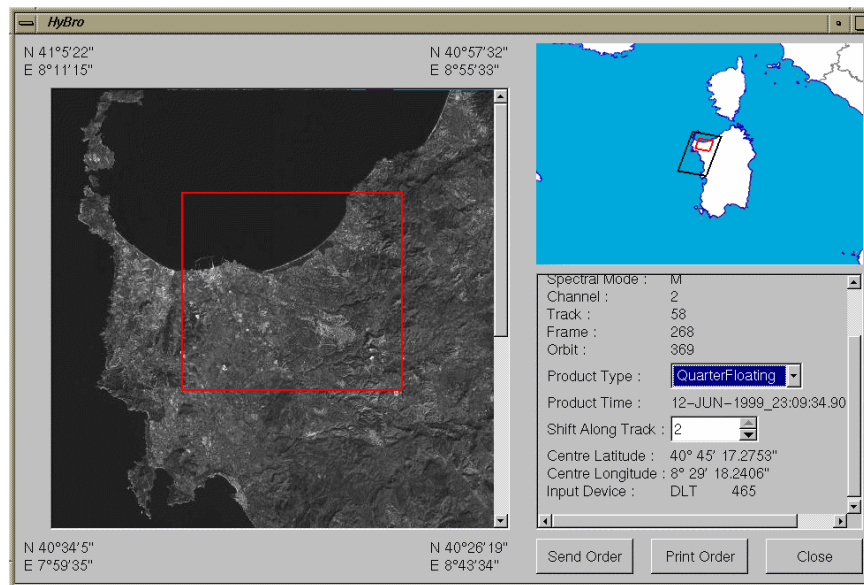


Figure 8 – Order panel (example)

The order panel will display a quicklook image of the selected product and the user can place a production/processing order for that product.



2.1.3 PROCESSING CAPABILITIES

The ECS has processing capabilities, as a minimum, for SAR standard products of level 0 and level 1b. The ECS production is performed off-line starting from the archived data.

Generated products are available on CD.

The system generates standard products, as defined by satellite operators. Optionally, user defined products may be supported.

ACS has proprietary algorithms for ASAR data processing, developed using the state-of-the-art methodology and research results. Product generation processors have passed severe tests (certification) by the satellite operators, in order to assess the quality of the results and declare the conformity of the products to the standards.

The ECS SAR processor is a customisation of the in-house developed Generic ACS SAR Processor (GASP). GASP is a SAR processing system capable of processing raw SAR data acquired by various SAR systems (which may differ in wavelength, attitude steering strategy, number and ordering of active beams, chirp characteristics etc.) into high resolution SAR images. Its broad applicability has been achieved by:

- Providing the most widely validated processing algorithms: the Range Doppler (RD) Algorithm and SPECAN, both applicable to all sensor modes, although RD is especially suitable for the strip-map imaging mode, while SPECAN is particularly appropriate for various burst imaging modes (ScanSAR, Alternating Polarization);
- Providing efficient and robust algorithms for Doppler centroid and rate estimation, adequate for the particular imaging mode and processing algorithm;
- Providing a high level of control via external configuration files and providing nominal values for all configurable parameters in accordance with the operating agency standards;
- Supporting a variety of input formats and methods for I/Q raw data decoding and conversion into the internal float format and saving the outputs as metadata files (an image file and an annotation file);
- Providing transparent interfacing to external data formats;
- Using only standard, fully cross-platform portable Unix mechanisms (e.g. SGI/Irix, PC/Linux).

High throughput performance is achieved by:

- Performing block-wise disk-to-disk computing, which encompasses all processing steps from the raw data block to the image block, such that no intermediate files are needed;
- Using high-granularity parallelization, which is scalable by the number of CPUs, involving minimal overhead;



- Selecting a set of configurable parameters which establish an effective trade-off between accuracy requirements and throughput requirements and which insure the optimal usage of the available working memory and the available number of CPUs.

These features make the GASP able to process a very wide range of raw SAR data, customizing only the configuration and control files and adding the appropriate libraries for ingestion of raw data and the specific auxiliary files. The formatting of the output to the desired standard L1b product is handled by post-processing, based on the metadata files.

2.1.4 PRODUCT EXAMPLES

In the following pages some SAR products processed by ACS are presented.



Figure 9 - RADARSAT Stripmap mode (Resolute Bay, CANADA) processed by ACS (2002) © Radarsat Int.

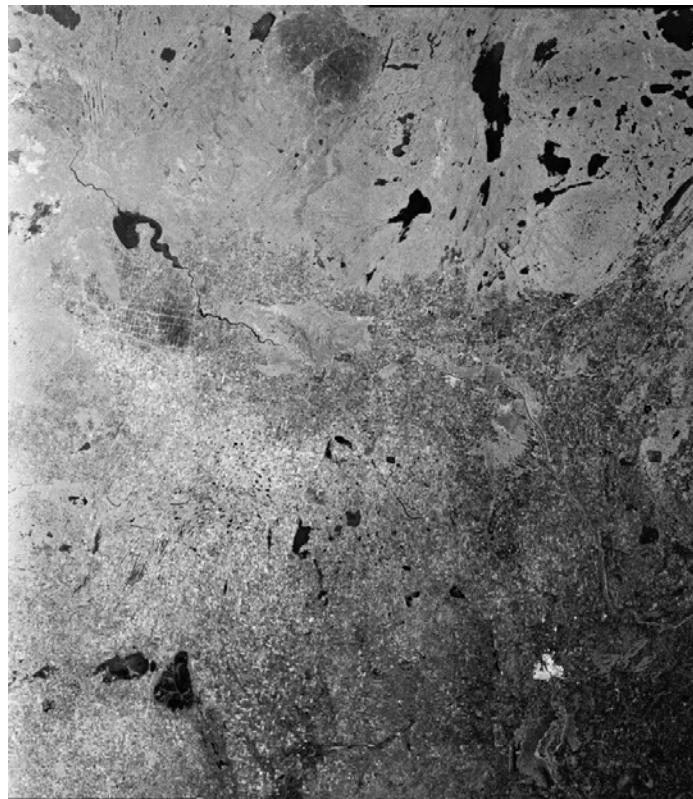


Figure 10 - RADARSAT ScanSAR mode (Prince Albert, CANADA) processed by ACS (2002) © Radarsat Int.



Figure 11 - ERS PRI image - © ESA 1998



The ACS processors, in operational use in the major processing centres, are kept aligned with the evolution of the algorithms and with the change in sensor behaviour along the satellite lifetime.

A quicklook processor is the crucial prerequisite for the browse function performing a quick look processing and creating the ASAR Browse Product and standard reports.

2.1.5 ASAR PRODUCTS

The ASAR products that can be generated by ECS are:

IMAGE

ASA_IM__0P ASAR Level 0 Image Mode

ASA_IMS_1P Image Mode SLC Image

ASA_IMP_1P Image Mode Precision Image

ASA_IMM_1P Image Mode Medium Resolution Image (stripline)

ASA_IM__BP Image Mode Browse Product (stripline)

Alternate Polarisation

ASA_APH_0P ASAR Level 0 Alternating Polarization (X-polar H)

ASA_APV_0P ASAR Level 0 Alternating Polarization (X-polar V)

ASA_APC_0P ASAR Level 0 Alternating Polarization (Co-polar)

ASA_APS_1P Alternating Polarization SLC Image

ASA_APP_1P Alternating Polarization Precision Image

ASA_APM_1P Alternating Polarization Medium resolution Image (stripline)

ASA_AP__BP Alternating Polarization Mode Browse Product (stripline)

Wide Swath

ASA_WS__0P ASAR Level 0 Wide Swath

ASA_WSM_1P Wide Swath Mode Medium Resolution Image (stripline)

ASA_WS__BP Wide Swath Mode Browse Image (stripline)

The browse products are used for the Catalogue.

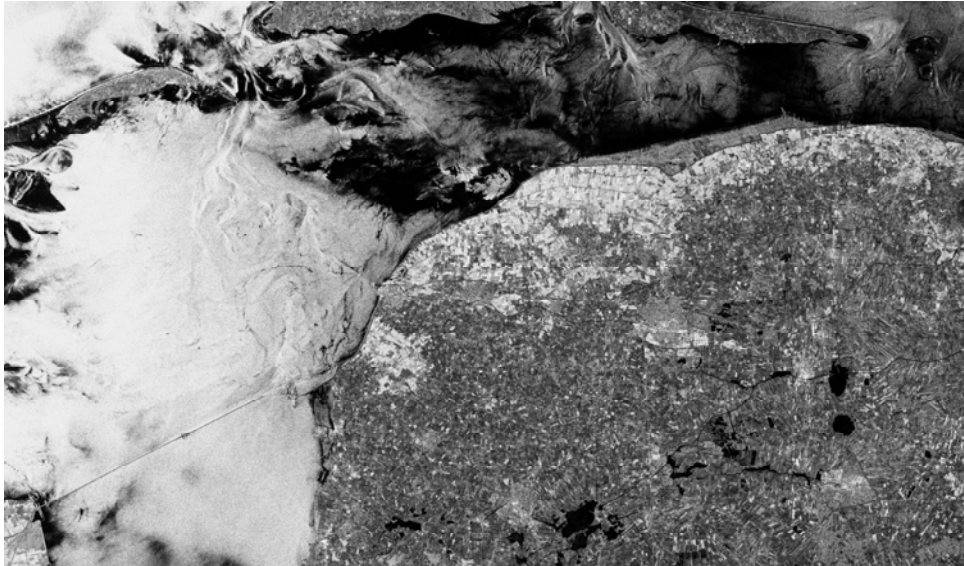


Figure 12 – ENVISAT ASAR Beam IS1 – Image Mode, Range Doppler (© ESA 2003)

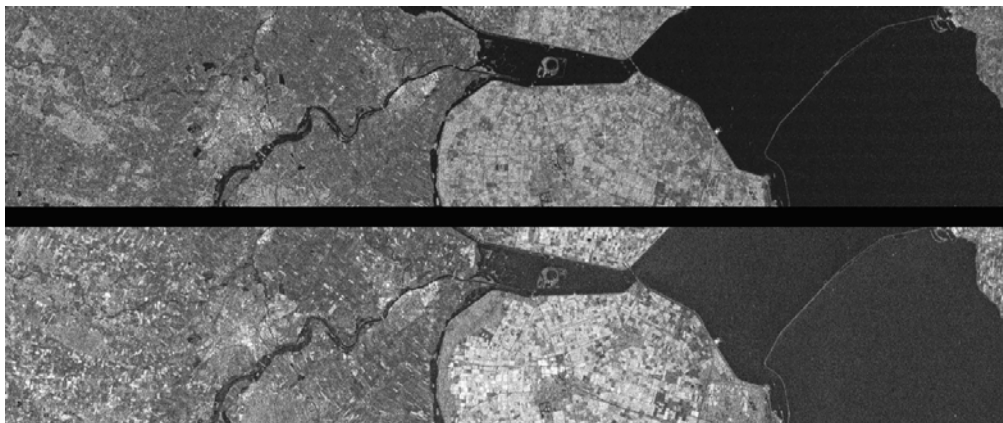


Figure 13 – ENVISAT ASAR Beam IS3 - APP, Precise Alternate Polarization, Specan (Flevoiland, Netherland)
VH(Up Image) - VV(Down Image)
(© ESA 2003)

2.1.6 ARCHIVING/TRANSCRIPTION ON MEDIA

Between ingestions or during the blind orbits, according to the operator shift management, the operator manually activates the archiving/transcription of the passes onto DLT in ESA archive format.

When a complete cassette is filled the operator should dismount the cassette, initialise a new one and continue archiving/transcribing passes.



2.1.7 STATION MANAGEMENT

A common advanced human interface software layer (Station Management) provides tools to manage and monitor station activities. The user interface is designed to facilitate operations and training of the operators. The ECS station management function handles the internal scheduling, sequencing and synchronisation of the different functions of the system.



2.2 ECS HARDWARE CONFIGURATION

The MDPS is hosted on a hardware configuration based on UNIX platforms. The MDPS is designed for a large scalability of the hardware configuration, depending on the required performance: It can run on a simple configuration (compact) or it can be hosted on a large configuration, where specific functionalities have dedicated platforms, with redundant hardware meant to provide maximum reliability and throughput.

The proposed HW configuration for the ENVISAT Compact Station is schematised as follows.

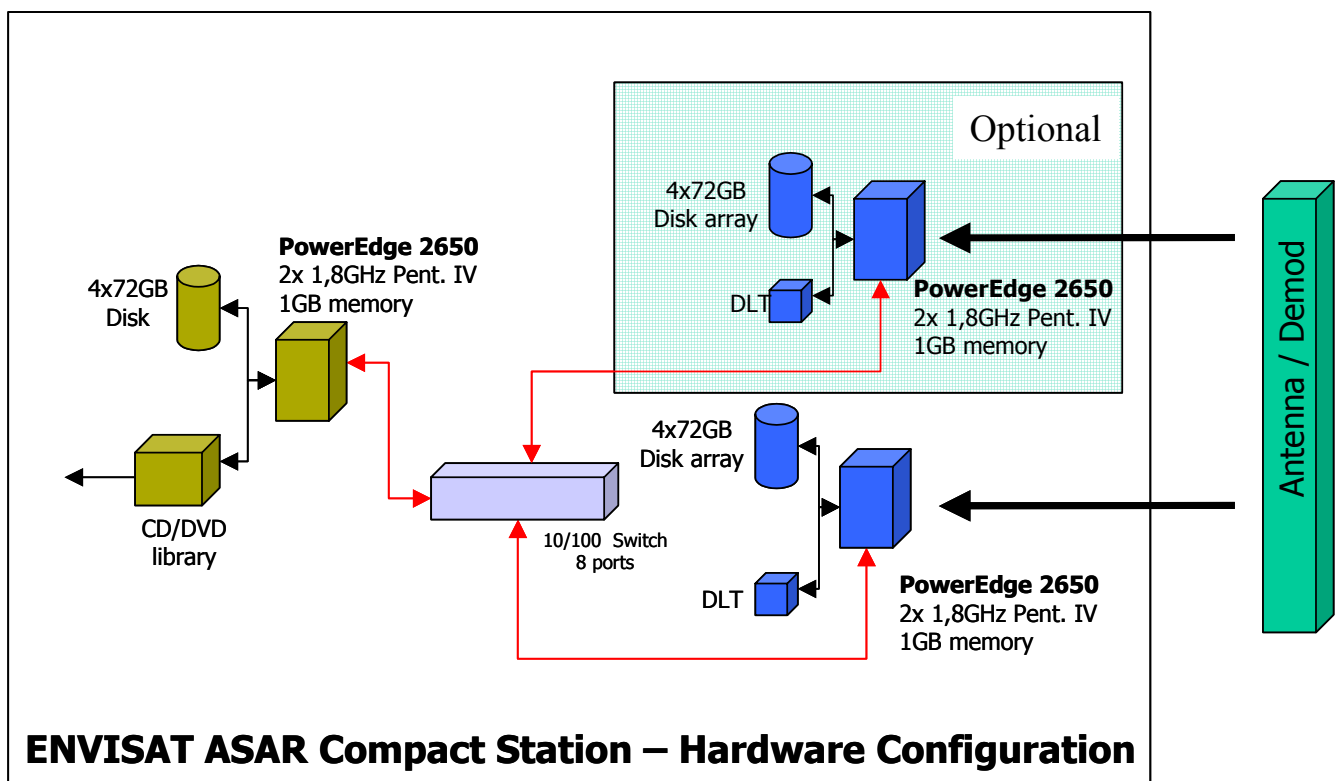


Figure 14 - HW configuration for ECS System

The modular approach offers maximum flexibility and provides an evolving capacity to the system, that can start with a minimal configuration (such as the above proposed one) and be upgraded to a larger one, with complete protection of the investment.



The ECS HW lay-out is depicted in the following figure:

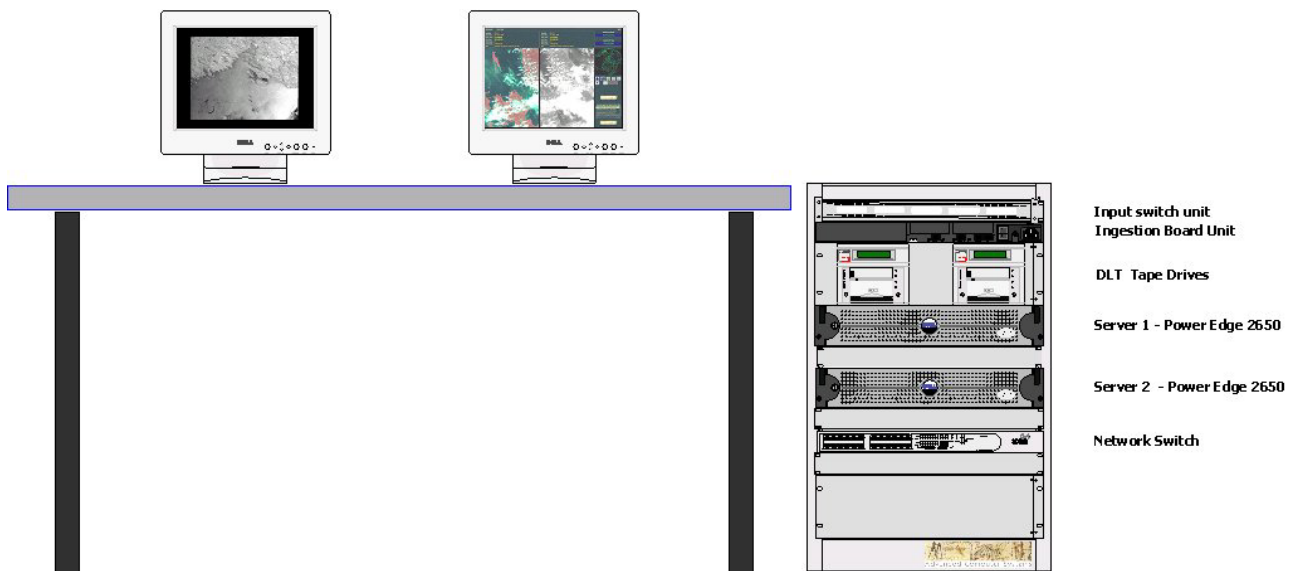


Figure 15 – ECS Compact Hardware Lay-out



3 ACS SERVICES

3.1 SUPPORTING ACTIVITIES

In addition to the ENVISAT ASAR Compact Station, Advanced Computer Systems provides the Customer with the following items:

- System Installation and test on-site.
- Operational Documentation (according to ESA standards).
- Operational Training.
- One-year warranty on hardware and software, with upgrade of software in case of new releases.

The above services are routinely included in the Compact Station delivery.

ACS can also offer maintenance of the system, beyond the warranty period.

On request, ACS can also provide additional training (operational support), to cover the first weeks of system's operational activities.

ACS can also provide the customer with extensive training, to support an extensive knowledge growth, and to help in the activation of data exploitation activities. Included are stages for customer personnel at ACS and specific on-site training in image analysis and processing and EO data applications.

3.2 DELIVERABLE DOCUMENT LIST

The ECS System is delivered with the following associated documentation:

Deliverable Number	Name
D1	ECS Acceptance Test Procedures
D2	ECS User Manual

3.3 PROJECT PLANNING

The system will be ready for start of operation within four months from reception of order.

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